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ABSTRACT

This paper describes the origins of a corporation producing computer software for children, lists criteria for software design, and describes work done with computer graphics for children. The corporation, called The Learning Company, had its origins in a project set up to create playful learning programs for children ages 3 to 13. The project was funded by grants and, when the second grant was received, a corporation was formed with the purpose of producing logic and geometry programs for 7- and 8-year-old gifted children. Subsequently, venture capital financing was obtained and the company was founded. Tests of the software produced indicate that children as young as 3 can use both graphics editing programs and graphics-based computer learning games to gain spatial and prereading concepts. Children as young as 7 can create and transform representations of three-dimensional objects on a computer, learn about computer logic circuits, and work with programs that can help them prepare for the computer age. According to the author, the capabilities of young children using computer graphics are only beginning to be explored; researchers may soon need to revise models of child development to match preschoolers' performance with computers. (Author/RH)

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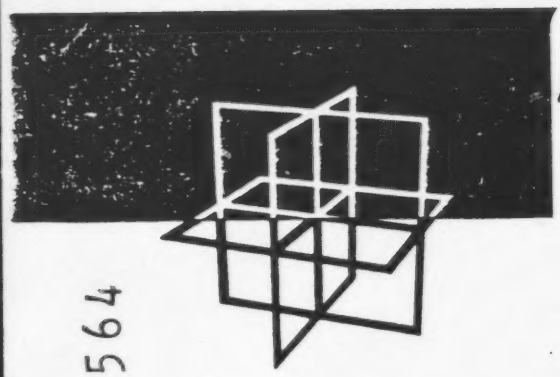

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"YOUNG CHILDREN USE COMPUTER GRAPHICS"

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YOUNG CHILDREN USE COMPUTER GRAPHICS

ABSTRACT

Children as young as three can use both graphics editing programs and graphics-based computer learning games to gain spatial and pre-reading concepts. Children as young as seven can create and transform three-dimensional objects on a computer, learn about computer logic circuits, and work with programs that can help them prepare for the computer age. This paper describes work done with computer graphics for children under two grants and with the help of venture capital financing at The Learning Company.

CREATING COMPUTER GRAPHICS FOR CHILDREN

Several years ago, I became fascinated with what children could do with low-cost microcomputers, particularly with colorful graphics. I started a company to create playful learning programs for children aged 3 to 13. The focus of the company was to design, program and test colorful, interactive software that challenges children to explore concepts they will need in the computer age -- spatial concepts, motion geometry, plotting 3-dimensional objects, logic, and circuit design. I found a programmer to work with and sought grants to get started in this venture.

Our first grant was from the Apple Education Foundation. We created programs for very young children and tested them at Stanford University's Bing Nursery School. The programs used color graphics, music, and voice to present pre-reading concepts.

Our second grant was from the National Science Foundation/National Institute of Education. When we received this second grant, we formed a corporation and set out to create logic and geometry programs for seven-

and eight-year-old gifted children. We tested programs in Palo Alto, California schools, offerring both graphics editors and new programs for bright young children.

New programmers interested in children's learning with graphical software joined our group, and we published Moptown ,children's logic games, and Magic Spells, a word unscrambling game, through Apple Computer, Inc. The graphics in these and many of our later programs were created by Cori Grimm, who first published computer art with us at age ten.

Following these grants, we changed the focus of the company to include marketing, and obtained venture capital financing so that we could continue this work. With this beginning, The Learning Company was founded. We have now released eight products for children, using Apple II computer graphics. We are developing programs for Atari and other computers, all featuring playful learning games for children aged 3 to 13.

Background

I began exploring microcomputers after spending many years as an educational researcher. I had worked

on designing packages describing effective reading and mathematics projects so they could be used with poverty-area children nationwide. I purchased the materials that showed up in several model projects and tried them with children to analyze what made them effective. The were playful, success-oriented, and presented information in manageable bits. I saw a special opportunity in low-cost microcomputers to offer learning programs in a new genre, and began working with an Apple II computer with my daughter, who was then two years old.

I wanted my child to use the computer playfully, not to wait for it to do time-consuming tricks between her keypresses. I wanted her to have time to think about what was happening, not be defeated by little flying balls on the screen. I wanted her to have surprises, to discover things experimentally. I wanted her computer experience to resemble sandbox play, not a game arcade or old teaching machine. I wanted the computer to generate consequences to her actions, but not beep and flash, "WRONG! YOU LOSE!." I wanted the computer's messages to be as considerate as those of her nursery school teachers.

Early Spatial Concepts

Our first program, developed with a grant from the Apple Education Foundation, presents pre-reading concepts on the Apple II -- "above" and "below , "left" and "right". Typically, when a child starts to learn reading and writing the teacher stands at the blackboard, draws a line, and tells children, "Start at the upper, left corner of your paper, put down the pencil above the line, and curve to the right to make a circle." The five-year-old child may not deal easily with so many abstract words in one sentence. The activity is easy, but the teacher's directions are not. To help children prepare to follow directions like these, we designed a series of programs starting with Juggles' Rainbow. The computer can help children learn abstract concepts. How? Visually, interactively, playfully.

There are three programs in Juggles' Rainbow. In the first, we divide the keyboard in half horizontally with a strip of blue paper to help children learn the concepts of "above" and "below". There are keys above and below the strip of paper. Children can press any key and something will happen on the screen -- colored

bars foreshadowing the tails of letters, boxes filling with color, rainbows with dancing rain. With each keypress there is music to enliven the exploration.

The second Juggles' program was built on the first. For teaching concepts of "left" and "right", a blue paper strip divides the keyboard vertically. There are keys on the left and on the right of the paper. The children press keys to make colored bars appear from the top to the bottom of the screen, to make a line move to the left and to the right of a circle, and to make a butterfly take shape with random new wing colors and music.

For the third Juggles' program, children use both blue strips on the keyboard. When they press a key -- above/left for example -- a colored box appears in the corresponding quadrant on the screen. After children master that, the computer can introduce four of the hardest letters of the alphabet: "b", "p", "d" and "q", which have four "tails" facing four ways. Then they can play with a windmill with cycling colors in four quadrants of the screen. These programs offer both reading readiness work, and a comfortable, playful computer experience for little children.

Bing Nursery School, a research facility of Stanford University, invited us to try out the programs with children aged 3 to 5. We set up the computer as an interest center in a classroom, which children could approach during indoor play time when they wished.

On the first day, 20 children, six parents, five teachers and a reporter from the London Times gathered around to watch while children had turns on the computer. After a few days, children learned that they would all get turns so they went about their business with blocks, clay, paint, dress-up clothing, puzzles and other materials. Parents visited, some spending the whole morning at the nursery school until they were sure their children would have turns.

Because the one computer was in such demand, children had five-minute turns. Some were one-trial learners, mastering the program the first time through. Others had three or four turns before they got the idea of what was happening. The programs had play sections and "following directions" sections, so children could test their mastery of concepts, and we could see how they were doing. We had planned the rainbow, butterfly, and windmill sections as rewards, but these wordless, playful activities proved to be powerful teaching tools

as well. Children wanted to finish the interesting patterns and make music play and colors cycle. So they figured out the concepts necessary to make this happen.

The computer remained busy at Bing, and before long a four-year-old started writing down children's names for turns, which seemed remarkable to the teachers. Usually there were many children on the waiting list. Some children met us at the door and asked to be first. After a turn, they would immediately put themselves down again on the list, and slip in for a third turn toward the end of the session. These children may be the computer wizards of the future.

We tested children in the Bing pilot study to get an idea of whether they were learning the concepts. About twice as many children passed concept tests after using the programs than had before using them.

We tried out other programs with the children and found they mastered the joystick and paddles quickly, and cooperated in playing games. Their computer activities were far from solitary. Children arranged to bring their friends for shared turns; they talked with teachers and other children about what they were doing; they drew pictures and sang songs related to the

computer activity and asked questions about related concepts during outdoor play. Children alternated keypresses for joint creations and played color-matching and guessing games. It was quite rare to see a single child at the computer. Usually there was at least one "watcher," who shared ideas or watched quietly. Some children watched without wanting turns for a long time, especially when there was an audience. Other children could hardly contain their eagerness while waiting for a turn. Children vary in style, just like adults.

Boys and girls asked for turns equally. There was no sense that the computer was a boy's domain in preschool, although children readily identify "boys's activities" and "girls' activities" at that age.

We invited children to use the Apple Graphics Tablet. In a few minutes children could change pen color, change background color, select "draw" or "box" modes, and perform other Graphics Tablet functions. Their lack of reading did not pose much of a problem. Three-year-olds invented clues such as, "The first green box changes the colors." Children enjoyed saving pictures and being able to call images to the screen later. Children also enjoyed coloring picture outlines with Electronic Coloring Book, a color-fill program with

a "microscope" key that lets children see how the computer mixes colors for special effects.

Several television shows were made about the Bing project, including segments of Don't Bother Me, I'm Learning, Part II, by One Pass Video, and Ruff Reports, to aire in Boston in August, 1982.

The capabilities of young children using computer graphics are only starting to be explored. Researchers may soon need to revise models of child development to match preschoolers' performance with computers.

BASIC SKILLS FOR THE COMPUTER AGE

In considering what young children could do with a computer with graphics display capability, we thought it would be interesting to work with children who are just starting to reason in a new way, and to conceptualize space differently than they did in early childhood. We were aware that children would face quite a different world than their parents and teachers, and that the computer could help prepare them for the many computer-based activities they would engage in in the technology age.

In 1980, we began creating logic and geometry programs for gifted children, aged 7 and 8, with support from a National Science Foundation/National Institute of Education grant.

Our team included an Assembly Language Graphics programmer, a mathematics educator, and an early childhood researcher. The grant provided an opportunity for us to spend many hours sharing the perspectives of our respective fields. We discussed many possible approaches to using a microcomputer with young children, analyzed capacities of gifted childdren, and obseved children using computers. We used and analyzed existing software, and had many design meetings. During the early weeks of the project, each of the members of the team learned a great deal from the others. It was necessary to define and learn uses of technical terms from computer science, mathematics, and child development, and to share what the we knew from each of these fields.

It was also necessary to explore the limits of what could be done with low-cost computer graphics, and with young children, who have processing and memory limitations of their own.

We found several commercial graphics software editors which had useful features for this project. These graphics editors could be used to create children's software, or better still, children could use them as tools.

Geometry Programs

The graphics editors we used included Robinett's Discovery Tool (The Learning Company), Budge's 3-D Graphics System (California Pacific Computer), Graphics Tablet (Apple Computer, Inc.), and E-Z Draw (Sirius Software).

We tried out both software tools and application programs with young children. Because existing software offered rich learning possibilities we used used commercial graphics editing programs with children to build geometry concepts such as open and closed curves, plotting coordinates in 3-dimensional space, performing motion geometry transformations, and defining polygons on the computer. We presented these programs in home and school settings and found children quite interested in the programs and, with help, able to use them fluently.

Bill Budge is the author of several best-selling game and utility programs, including 3-D Graphics System, an editor used to create white line drawings which can be transformed under the operations of motion geometry.

To use 3-D -Graphics System, children need to plot numbers using X, Y, and Z coordinates, with both positive and negative numbers. The Learning Company created a series of games, called Bumble Games and Bumble Plots to help children learn these.

Bumble Games and Bumble Plots feature a creature from the planet Furrin, Bumble, who was invented by Cori Grimm. Bumble thinks of secret numbers, asks children to help him find his lost butterfly, to trap his bug, to block the escape of robbers, to seek hidden treasure under the sea, and to play Tic Tac Toc, using coordinates to plot locations on grids and arrays. The games range from easy to hard, so that very young children can start to learn the basics of plotting.

In the first game, a number line appears, and children guess a number by pressing a numeral key. The computer says whether the number is greater than or less than the number guessed, with an arrow for non-readers.

The number line is displayed horizontally in the first game, vertically in the second, and alternately thereafter to help children get used to the orientation of X and Y coordinates. In the second game, children name a position in a array, using letters for X and numbers for Y. The computer prompts them with arrow clues until they guess the number. The computer also draws lines through the array to show where the X and Y coordinates intersect according to the child's guess. Children get used to naming X first, then Y, and to the terms for row and column. Then the next game is more demanding, giving no picture clues and eventually asking children to use standard notation for their entries.

We were surprized to see four year olds use the last program on the disk, plotting Bumbles pictures and using the editor built into the program to plot original pictures.

One criticism of these programs from a university reviewer was that they do not test the children on their knowledge. We feel that the child's competance at making the games work is the best test. The reward is internal -- the game works quickly and in a satisfying way when the concepts are being learned. When the games are mastered, children move on to harder games. They

are experts at finding their own learning edge.

After using the programs in Bumble Games and Bumble Plots, children in our NSF/NIE project used 3-D Graphics System to plot 3-D objects and spin, flip, slide, and rotate them along three coordinates. It would be interesting to know how this work affected their space perception and visualization ability at ages 7 and 8. They fluently mastered the plotting activities and invented objects to transform.

E-Z Draw is another graphics editor used to create popular video games, but it has no animation features. E-Z Draw allows children to create two-dimensional colored shapes, such as irregular parallelograms, squares, rectangles, and triangles, using the keyboard to control a cursor on the monitor screen. Children set the shapes to be made, e.g. "P" for parallelogram, then set two corner positions, and watch the shape appear. Color controls make this program difficult to operate, but it offers many possibilities for building geometry awareness.

Similar awareness can be built by using the more expensive Apple Graphics Tablet, or the public domain editor from Blocks, Edu-Paint, distributed by Softswop

at California's San Mateo County Office of Education.

Children also enjoyed creating animated objects in colorful graphics worlds using Warren Robinett's Discovery Tool. Discovery Tool is a graphics editor used at The Learning Company to create fast animated learning games, using many screens connected in a large map. Children using Discovery Tool have used the draw function to create dancing skeletons, ghosts that float around, flying birds and snakes, and other animated objects. They have enjoyed exploring the geography of sixty-four room worlds and inventing unexpected new topologies, playing with animated trains, torches, buzzers, and box-drawers. They get quite excited driving their cursor away from snapping all'gators chasing them on the screen, and inventing ways of coping with the alligators. They enjoy both the editing tool and the games created with it.

Discovery Tool is a powerful tool for creating colorful, animated graphics, and works with a user-friendliness we think will characterize computers of the future. Changing colors can be done by dipping objects in color pots. Changing shapes can be done by entering a drawing room and cruising around with a joystick to draw and erase. We think Discovery Tool

will offer new possibilities for children creating their own programs.

All the programs described here use the microcomputer in ways that cannot be duplicated on paper and that give children first-hand experience with generating graphics.

Logic Programs

We found that the topic of early logic was not as well-developed in commercially available programs as was geometry. We created prototype programs, called Logic Tools, under the NSF/NIE grant, then continued product development to create more products in this genre.

Gertrude's Puzzles is a set of logic puzzles for younger children and Gertrude's Secrets is for older children. Both programs were created at The Learning Company, following our NSF/NIE grant work.

These programs include Venn diagram puzzles, Graeco-Latin Square puzzles, and pathway difference puzzles. They require that children use a joystick or keyboard to place objects in various boxes to create patterns. To make the game operate quickly, we placed

Gertrude, the go-getter goose in the entry room for each set of puzzles. Children drive a cursor to the goose's nest and pick her up by pressing the joystick button. When they drive to a puzzle room and let her go, Gertrude flies off to the storeroom and delivers an appropriate set of playing pieces for each puzzle. Children arrange puzzle pieces using a joystick, then the computer tests whether the puzzle pieces are placed logically. The computer floats pieces out of their boxes to help children discover the rules governing each puzzle pattern. Children as young as four years old surprised us by playing these puzzle games with a consistently logical approach.

Logic Gates is another logic program created under the NSF/NIE grant. Logic Gates has two sections. The first section has room with working logic symbols like those used in computer circuit design -- "and", "or", "not", and "flip-flop". There are also little effectors such as boffers (gloves and boots), clackers and thrusters. And there are detectors that indicate where other objects are located, and transmit signals based on the presence of certain kinds of objects. Using these simulated objects, children can explore working logic gates, which turn red or white depending on their logic state. The subject of computer circuit logic, which is

usually not introduced before the college years, becomes very concrete for young children when it is taught with working models of logic elements.

Children can make large machines by connecting logic elements with effectors and detectors, then take their machines to try out in the other part of the game program. Logic Gates has a gator gate, which blocks the entrance of firece little simulated alligators into the logic circuit workshop. Once in the gator maze, the cursor is suddenly attacked by hungry alligators who snap away at it until it disappears. There are seven treasures in the gator maze. To help in the quest for treasures, the child can make thrusting/punching alligator detectors with logic gates attached to them. They can send out little machines of their own design to clear out the alligators before they venture into the maze. There are fourteen nasty alligators, all of which lurk near the treasures, then start chasing the cursor and eating it when it approaches the treasure.

Rocky's Boots, a new TLC product, offers tutorials and a game using wires with input sockets and output arrows, logic gates, flip flops, clocks and delays to teach the principles of combinatorial and sequential logic. We consider this to be a landmark program for

computer-age learning. Children build circuits to activate a kicking device in many logic games. They can also create their own game in an editing room.

Children's Learning

Young children become very involved using graphics-based computer programs. They seek turns of an hour and longer, on a daily basis. They design complex logic circuits on the computer, and solve many logic puzzles. They plot objects and transform them on the computer.

Graphics-based programs were so popular in our preschool field test, that Bing now has three microcomputers in daily use. In the NSF/NIE field test school, the parents volunteered to keep the computer room open during recess, lunch, after school, and into the evening during the entire field test period.

Microcomputers offer exciting possiblities for young children to learn concepts while exploring computer graphics. They can quickly master the tools used by programmers to create valuable and interesting computer art, and build logic skills for the computer age.